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Spraying Program and Pest Control in the Orchard

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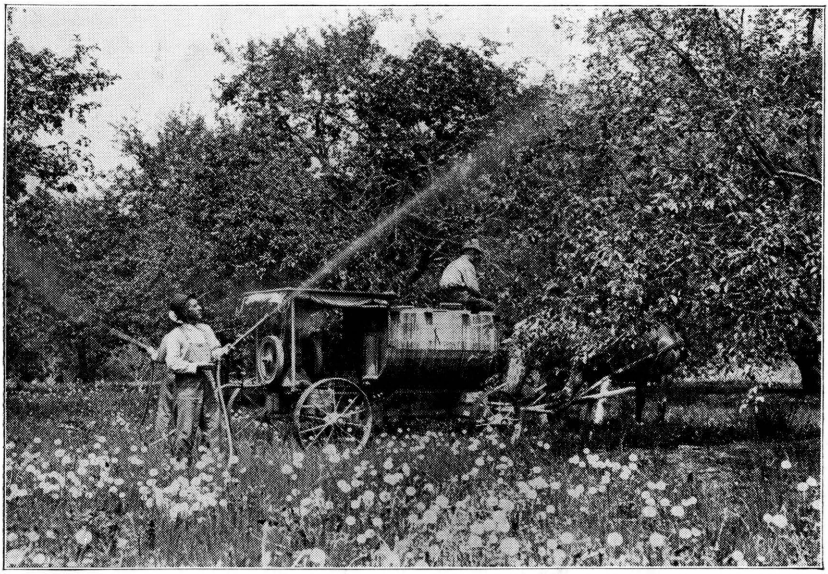


Spraying in the variety orchard, Ohio Experiment Station

SPRAYING PROGRAM AND PEST CONTROL IN THE ORCHARD[1]

The many orchards in Ohio represent a wide range in conditions, such as age of trees, location, cultural practices, varieties, and susceptibility to insects and diseases. A spray program cannot be formulated that will meet the requirements of each individual orchard. Seasonal variations, orchard cultural practices, and general environmental conditions largely govern the severity of both fungous diseases and insect outbreaks. For these reasons some orchards may require a rigid or complete spray program to control pests, while in others, during the same season, such a program may not be necessary.

Spraying should be looked upon as a form of insurance. Important sprays should not be omitted unless the grower is reasonably certain that he can afford to carry the risks that will develop in the absence of spray protection.

Changes in spraying procedure become necessary from year to year. This is due, in part, to the ever changing conditions concerning the pests against which the treatments are directed and, in part, to the development of new sprays and to new information concerning older ones. Rapid advances are being made in perfecting spraying materials, and new ones are continually appearing on the market.

This bulletin discusses the standard spray materials now offered for sale and suggests proper combinations that will control both insects and diseases without causing spray injury to the fruit and foliage. It has been prepared after considerable discussion of the effectiveness and safety of the materials and combinations suggested, these having been thoroughly tested and approved.

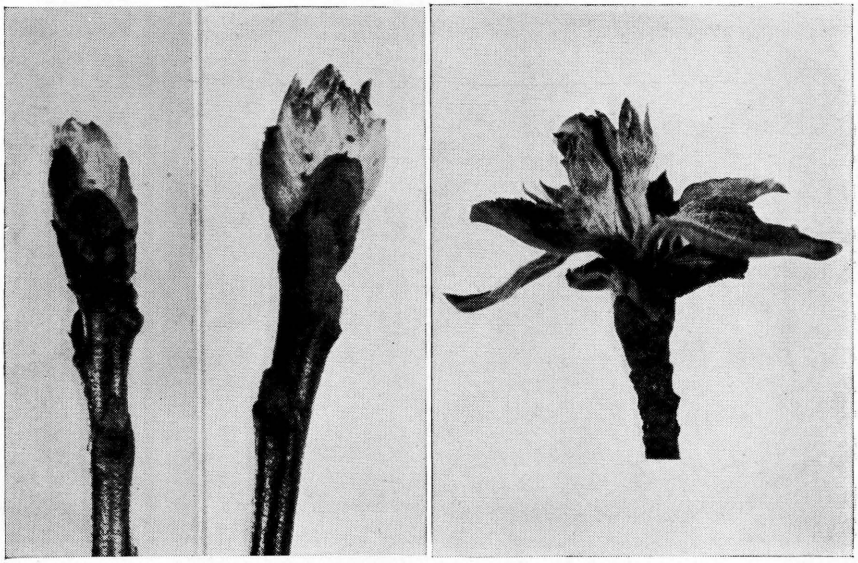
The three main considerations in successful spraying are: *correct timing, thorough application,* and the *use of proper materials.* These are the "big three" responsible for success in spraying, and if any one is neglected the structure falls, for without all three of them success cannot be attained.

THE OHIO SPRAY SERVICE

The Ohio Spray Service is entirely informational and deals largely with the timing of sprays. From a small beginning in a few counties, it has grown until now the entire State is included.

[1]Prepared by the Departments of Botany, Entomology, and Horticulture of the Ohio State University and the Ohio Agricultural Experiment Station.

The information is distributed by the Extension Service of the College of Agriculture of the Ohio State University and is of two general types: (1) letters or cards and (2) radio broadcasts. The information upon which recommendations are based is collected from all parts of the State and assembled at Columbus. Suggestions on the necessary spraying procedure are then sent to the county agents, who, in turn, notify every fruit grower on their mailing lists.



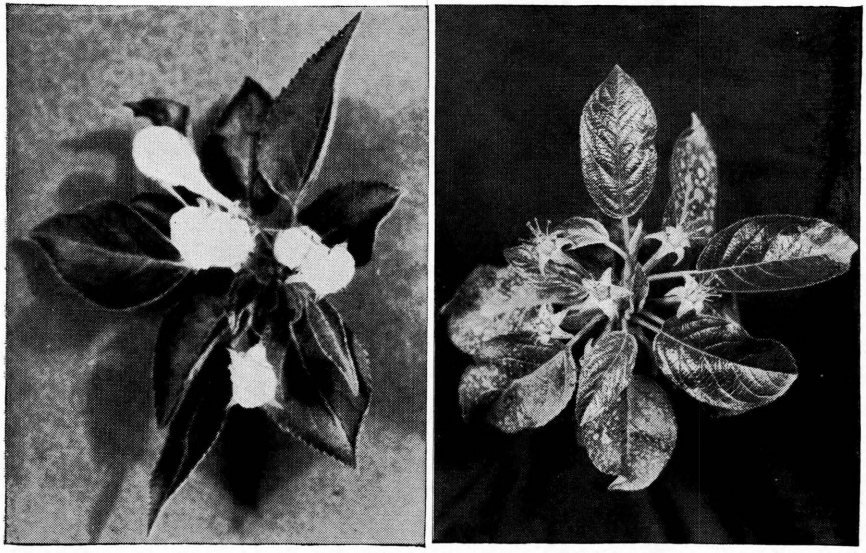
(a) (b) (c)

Fig. 1.—Three early steps in bud development:
(a) Silver bud stage. (b) Delayed dormant stage. (c) Pre-pink stage

Each fruit grower is sent a letter or card for each apple spray. Following this no further information is necessary for the dormant or delayed dormant sprays. For the pre-blossom spray or sprays a letter is mailed in advance giving all the necessary information, except the time of application. The time for spraying is announced over the radio for each fruit section. A letter giving the exact time and place of broadcasting is sent each spring to all fruit growers who are on the county agents' mailing list.

The calyx spray is timed by the fall of the petals and no further information is necessary than that contained in a letter. Information regarding the need of a 10-day or 2-week spray is disseminated over the radio and by letter. The dates for applying the

first brood codling moth cover spray and the midsummer spray are given by letters or cards sent to the individual growers; the time for spraying varies for the different fruit sections. These letters are supplemented by weekly radio broadcasts.



(a) (b)

Fig. 2.—Two further steps in bud development: (a) Pink stage. (b) Calyx stage

Every fruit grower in the state of Ohio is entitled to receive this spray information. This service is free, and those desiring it should make their wants known to their local county agent.

SPRAY PROGRAMS FOR CONTROL OF INSECTS AND DISEASES

APPLE SPRAY PROGRAM

TABLE 1.—Spraying Program for Apples

Name and time of spray*	To control	Materials to use	Further suggestions
DORMANT In spring when buds are dormant or beginning to swell	Scale Red mite	Oil emulsion 4½ gal. or miscible oil at manufacturers' recommendations or Liquid lime-sulfur 12½ gal. or Dry lime-sulfur 30 lb. Water to make 100 gal.	Use oil if red mites are serious. (Spray thoroughly.)
OR			
DELAYED DORMANT When blossom buds show ½ inch green	Scale Scab	Lime-sulfur as above	Oils sometimes cause burning in the delayed dormant. If rosy aphis is a problem, add 1 pint of nicotine sulfate to 100 gallons of the lime-sulfur spray.
PRE-BLOSSOM (Pre-pink and pink) Following delayed dormant and before blossoms open (Watch Spray Service Recommendations)	Scab Black rot (Frog-eye)	**Dry lime-sulfur** 7 lb. or Liquid lime-sulfur 2½ gal. Water to make 100 gal.	If canker worms, curculio, or bud moths are troublesome, add 3 pounds of arsenate of lead. (Spray on time and cover foliage well.)
CALYX-CUP When the last of the petals are falling	Scab Codling moth Curculio Canker worms	**Dry lime-sulfur** 6 lb. or Liquid lime-sulfur 2 gal. or Wettable sulfurs† and Arsenate of lead 3 lb. Hydrated lime 8 lb. Water to make 100 gal.	If red bugs or leafhoppers are pests, add 1 pint of nicotine sulfate. Southern Ohio should not use liquid lime-sulfur for this and following sprays. Lime is added to decrease burning. (Cover all blossom clusters.)
10-DAY TO 2-WEEK Not necessary every year (See under Suggestions)	Scab Curculio	**Dry lime-sulfur** 5 to 6 lb. or Liquid lime-sulfur 2 gal. or Wettable sulfurs† and Arsenate of lead 3 lb. Hydrated lime 8 lb. Water to make 100 gal.	This spray is necessary only: (a) where new leaves have some scab lesions or overwintering spores are still numerous on old leaves as told through the spray service, or (b) on varieties susceptible to blotch, or (c) where curculio is a serious problem.

TABLE 1.—Spraying Program for Apples—Continued

Name and time of spray*	To control	Materials to use	Further suggestions
FIRST BROOD CODLING MOTH 3 to 4 weeks after petal fall (Watch Spray Service Recommendations)	Codling moth Curculio Scab Blotch Brooks spot Bitter rot	Same as 10-day to 2-week spray except as noted under Suggestions	Dry lime-sulfur or wettable sulfurs† are preferred in all localities except where copper sprays are needed. In southern Ohio localities where Brooks spot, blotch, and bitter rot are serious, use 1-3-50 bordeaux mixture. (Coat every apple thoroughly.)
6 *WEEKS AFTER PETAL FALL* Necessary only in certain localities and in some seasons (See under Suggestions)	Codling moth Apple maggot	Same as first brood codling moth spray	This spray is necessary only: (a) where codling moth is difficult to control or (b) in some northeastern Ohio orchards where apple maggot is a problem.
MIDSUMMER 9 to 10 weeks after petal fall (Watch Spray Service Recommendations)	Codling moth Bitter rot Blotch Brooks spot Sooty fungus	**Dry lime-sulfur** 4 lb. or Liquid lime-sulfur 1½ gal. or Wettable sulfurs† or Bordeaux mixture (See page 23 and Suggestions, Col. 4) and Arsenate of lead‡ 2 lb. Hydrated lime 8 lb. Water to make 100 gal.	Avoid spraying if possible when temperature is abnormally high or spray injury may follow. For Brooks spot and blotch use 1-3-50 and for bitter rot use 2-6-50 bordeaux mixture. (Coat apples thoroughly.) Using more than 2 lb. of arsenate of lead increases risk of too much residue.

*The more important sprays are indicated by heavy type.

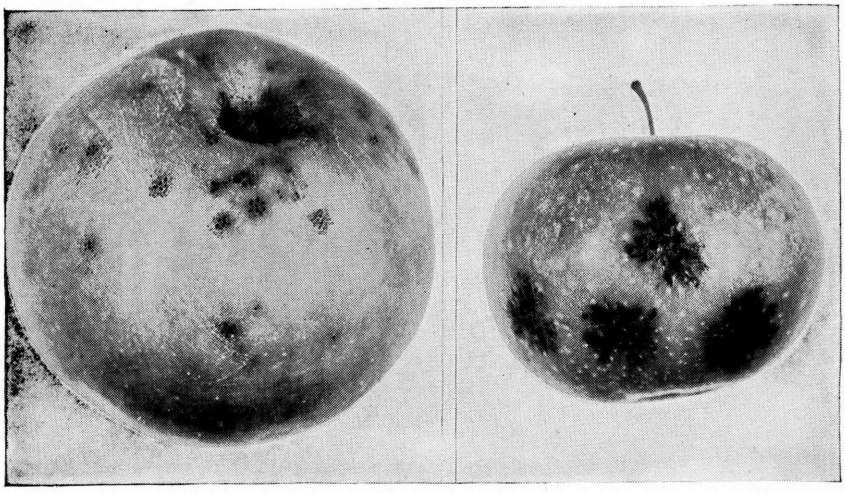
†Wettable sulfurs should be used at manufacturers' recommendations. These are discussed on page 22.

‡In some western states oil is being substituted for arsenate of lead in the midsummer spray. Information on the use of summer oils in Ohio is found on page 27.

The above program is of some value in apple flea-weevil control, but in severe outbreaks it is inadequate. There has been no spray program developed which will hold this insect in check. The most satisfactory control consists in *absolutely* clean cultivation which eliminates all grass, leaves, and weeds in which the adult weevils pass the winter.

DISTRIBUTION OF APPLE DISEASES IN OHIO

One of the reasons that a general apple spray program for Ohio must be somewhat complicated is the peculiar distribution of the disease-producing parasites. In general, there are four distinct diseases; namely, scab, Brooks spot, blotch, and bitter rot. Scab is general throughout the State, and the regular sulfur sprays should be used to protect against it.

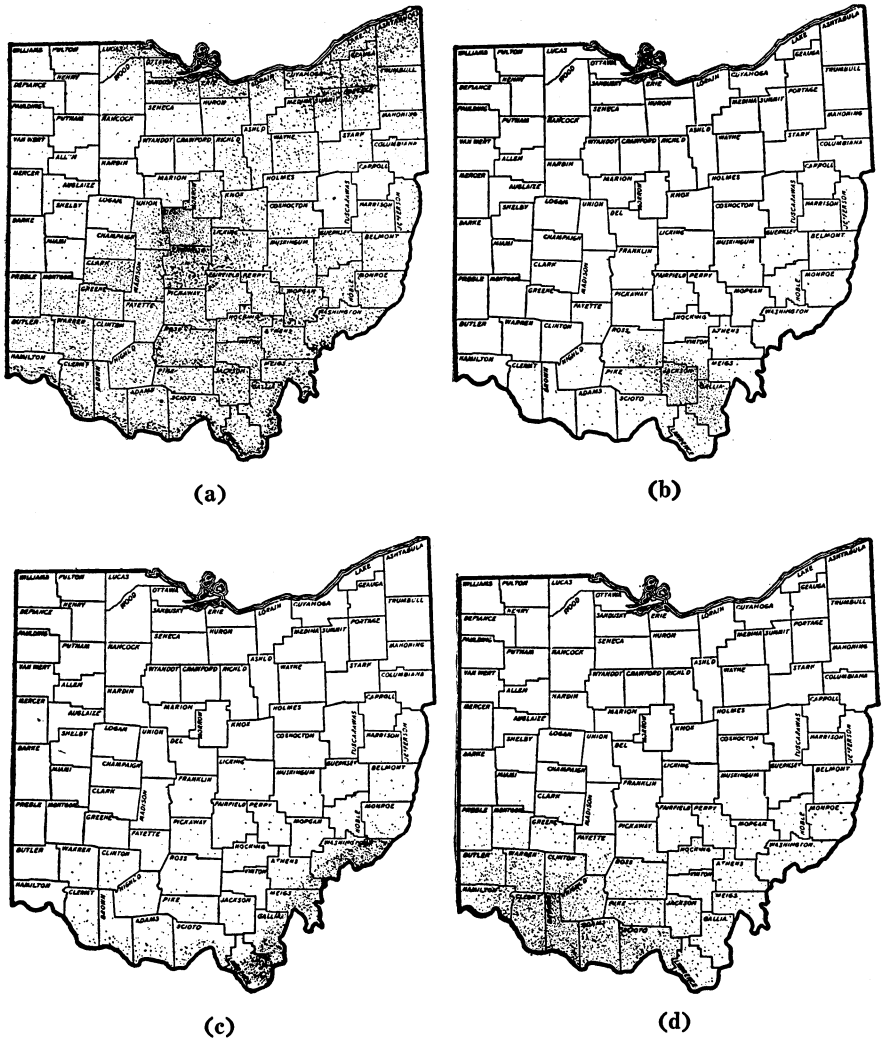


(a) (b)

Fig. 3.—These two diseases are controlled by bordeaux mixture (a) Brooks spot. (b) Apple blotch

Brooks spot, blotch, and bitter rot are confined largely to the southern apple-growing section. For their control, bordeaux mixture, as recommended, is the most effective spray at the present time. These diseases are best controlled during the summer, at which time bordeaux causes the least amount of injury to the fruit and foliage.

The accompanying maps show the general location of each of these diseases.



(a) (b)

(c) (d)

Fig. 4.—Four maps of Ohio showing:
(a) Distribution of apple scab. (b) Distribution of Brooks spot. (c) Distribution of bitter rot. (d) Distribution of blotch

VARIETAL SUSCEPTIBILITY TO DISEASES AND TO SPRAY INJURY

Every fruit grower has observed that apple varieties like McIntosh, Rome, and Delicious are more severely damaged by scab than are Grimes or Jonathan. A given variety may be very subject to scab and resistant to other diseases.

In Table 2 a general summary of the susceptibility of different varieties to diseases and to spray injury is set forth. By observing these facts in one's own orchard it is possible to make certain changes in the general spray recommendations to fit the individual orchard better.

TABLE 2.—Degree of Susceptibility of Ohio Apple Varieties to Diseases and Spray Injury

Variety	Scab	Bitter rot	Blotch	Brooks spot	Fire blight	Cedar rust	Bordeaux russet	Lime-sulfur russet
Yellow Transparent	Sl.	Sl.	Sl.	Sl.	Very	Sl.	Sl.	Sl.
Duchess of Oldenburg	Sl.	Sl.	Very	Sl.	Sl.	Sl.	Sl.	Sl.
Wealthy	Mod.	Sl.	Sl.	Sl.	Mod.	Mod.	Sl.	Sl.
Jonathan	Sl.	Mod.	Sl.	Very	Very	Very	Very	Mod.
Grimes	Sl.	Very	Sl.	Very	Very	Sl.	Very	Very
McIntosh	Very	.....	Sl.	Sl.	Sl.	Sl.	Sl.	Mod.
Delicious*	Very	Mod.	Sl.	Mod.	Sl.	Very	Sl.	Mod.
Stayman	Mod.	Mod.	Sl.	Mod.	Sl.	Sl.	Sl.	Mod.
Rome	Very	Sl.	Mod.	Mod.	Mod.	Mod.	Sl.	Sl.
Baldwin	Mod.	.....	Sl.	Sl.	Sl.	Sl.	Very	Very
Northern Spy	Very	.....	Sl.	Sl.	Sl.	Sl.	Sl.	Sl.
Rhode Island Greening	Mod.	.....	Sl.	Sl.	Mod.	Sl.	Mod.	Mod.
Winter Banana	Very	Mod.	Sl.	Sl.	Sl.	Very	Mod.	Mod.
Ben Davis	Very	Very	Mod.	Sl.	Mod.	Mod.	Very	Very

*Varieties like Delicious, Rome, Stayman, etc., include the red sports of those varieties.
Note: Sl. = Slightly susceptible; Mod. = Moderately susceptible; Very = Very susceptible.

Apple scab and fire blight attack vigorously growing trees more frequently and severely than trees of low vitality. The opposite is true of black rot and apple measles. Trees making poor growth are likely to be injured by sprays which do not harm vigorously growing trees of the same variety. The margin of safety for effective sprays is very narrow and constant search is being made for safer and better materials.

PEAR SPRAY PROGRAM

TABLE 3.—Spraying Program for Pears

Name and time of spray	To control	Materials to use	Further suggestions
DORMANT Before buds open or when beginning to swell	Scale Pear psylla Blister mite Red mite	Oil emulsion or Miscible oil	This spray is necessary only in case one or more of these insects are serious
CLUSTER BUD When blossom buds are separated in the cluster and before blossoms open	Scab Leaf spot	**Dry lime-sulfur** 7 lb. or Liquid lime-sulfur 2½ gal. or Bordeaux mixture 1-3-50 Water to make 100 gal.	This spray may be omitted where disease is not prevalent
CALYX-CUP When the last of the petals are falling	Codling moth Scab Leaf spot Pear slug Sooty fungus	Dry lime-sulfur 5 lb. Arsenate of lead 3 lb. Hydrated lime 8 lb. Water to make 100 gal.	Spray blossom clusters thoroughly
MIDSUMMER 9 to 10 weeks after petal fall	Same as for calyx-cup	Same as for calyx-cup except use 2 lb. of arsenate of lead	Avoid spraying if possible when temperature is abnormally high

STONE FRUIT SPRAY PROGRAMS

TABLE 4.—Spraying Program for Peaches

Name and time of spray	To control	Materials to use	Further suggestions
DORMANT In the fall after leaves are shed or in spring before buds swell	Leaf curl Scale Red mite	Liquid lime-sulfur 12½ gal. or Dry lime-sulfur 30 lb. Water to make 100 gal. or Oil spray combined with 2-4-50 bordeaux	Leaf curl is best controlled by fall spraying. If scale is not present, ½ the strength of lime-sulfur or 2-4-50 bordeaux is sufficient. Fall application of oil on peach is not advised because of possibilities of injury. For mixing oil and bordeaux see page 19.
SHUCK-FALL When shucks are approximately ⅔ off	Brown rot Curculio Scab	Dry-mix sulfur-lime 18 lb. or Wettable sulfur (see page 22) and Arsenate of lead 2 lb. Water to make 100 gal. or 80-10-10 sulfur-lime-lead dust (see page 43)	This is one of the most important sprays for peach. If arsenate of lead alone or wettable sulfur and arsenate of lead are used, add 4 lb. of hydrated lime to prevent burning.
2- or 3-WEEK 2 to 3 weeks after the shuck-fall application	Brown rot Curculio Scab	Same as for shuck-fall except the arsenate of lead should be omitted	If curculio is a menace add arsenate of lead to this spray.
ORIENTAL FRUIT MOTH		(See note)	
PRE-HARVEST 10 days to 2 weeks before the fruit is picked	Brown rot Scab	Same as for shuck-fall except omit the arsenate of lead	Wettable sulfurs or sulfur-lime dust leaves less residue on the harvested fruit than dry-mix.

Note. No spraying schedule can be recommended at this time that will give satisfactory control of the Oriental fruit moth. The use of large quantities of hydrated lime in early-season sprays, while of some value, is not recommended.

The best schedule developed thus far is four applications of a summer oil, 2 gallons to 100 of water, applied at 10-day intervals, beginning 6 weeks before picking time. The results of the work of two seasons indicate that reductions in fruit injury of from 50 to 80 per cent can be obtained in Elberta peaches by the use of this schedule. It has also resulted in fruit with a better color, has reduced the percentage of dropped fruits, and has delayed ripening to a certain extent. It is necessary, however, to spray thoroughly in an effort to cover the leaves on the under surface where the Oriental fruit moth eggs are usually deposited.

This treatment should only be considered for Elberta and later varieties, since the earlier varieties usually escape severe injury. It should be used in conjunction with the above spraying schedule for peaches, but it will be necessary to omit the pre-harvest application of sulfur; otherwise burning is almost certain to occur. The advisability of following this extensive spraying program will necessarily be governed by the value of the anticipated peach crop.

In setting out young orchards the planting of varieties that ripen later than Elberta is not advisable because of the fact that such varieties are more severely injured.

TABLE 5.—Spraying Program for Sour Cherries

Name and time of spray	To control	Materials to use	Further suggestions
SHUCK-FALL When the shucks are slipping from the young fruits	Leaf spot Curculio Brown rot	Liquid lime-sulfur 2½ gal. or Dry lime-sulfur 7 lb. and Arsenate of lead 2 lb. Water to make 100 gal.	In some seasons an earlier application may be advisable for leaf spot control. Watch Spray Service Recommendations.
FIRST COVER 2 to 3 weeks after shuck-fall spray	Leaf spot Curculio Brown rot Slug	Same as shuck-fall	This is a very important curculio spray.
SECOND COVER When fruits are beginning to color	Leaf spot Brown rot	Liquid lime-sulfur 2½ gal. or Dry lime-sulfur 7 lb. Water to make 100 gal.	This is a very important disease spray. If cherry maggot is a problem, include 2 lb. arsenate of lead in each 100 gal.
AFTER-HARVEST Immediately after fruit is picked	Leaf spot	Liquid lime-sulfur 2½ gal. or Dry lime-sulfur 6 lb. Water to make 100 gal.	This spray is important to protect the foliage. Cover leaves thoroughly. Trees which drop their leaves in midsummer set poor fruit buds for the next year's crop.

TABLE 6.—Spraying Program for Plums and Sweet Cherries

Name and time of spray	To control	Materials to use	Further suggestions
DORMANT	Red mite (plum only)	Oil emulsion 4½ gal. or miscible oils at manufacturers' recommendations	
DELAYED DORMANT When the tips of the buds first show green	Black cherry aphis (cherry only)	Liquid lime-sulfur 3 gal. or Dry lime-sulfur 7 lb. and Nicotine sulfate 1 pt. Water to make 100 gal.	This spray need not be applied on plums, except when infested with scale. Then 12½ gallons of liquid lime-sulfur or 30 pounds of dry lime-sulfur should be used.
SHUCK-FALL When shucks are about ⅔ off	Curculio Brown rot Leaf spot	Dry-mix sulfur-lime 18 lb. or Wettable sulfur (see page 22) and Arsenate of lead 2 lb. Water to make 100 gal. or 80–10–10 sulfur-lime-lead dust (see page 43)	This is one of the most important sprays for stone fruits.
FIRST COVER 10 days to 2 weeks after shuck-fall spray	Curculio Brown rot Leaf spot	Same as for shuck-fall spray	This spray is necessary for curculio control, and during years of abundant rainfall it is important for leaf spot control on sweet cherries.
SECOND COVER 2 to 3 weeks before harvest	Brown rot Leaf spot	Same as for shuck-fall, except that the arsenate of lead should be omitted	If one of the wettable sulfurs or sulfur dust is used, this application may be made 1 week before harvest and still not leave an objectionable residue. Sulfur dusts without lead may be applied during harvest whenever brown rot threatens.

GRAPE SPRAY PROGRAM

TABLE 7.—Spraying Program for Grapes

Name and time of spray	To control	Materials to use	Further suggestions
PRE-BLOSSOM Before blossom buds open. When new shoots are 12 to 18 inches long.	Mildew Black rot	4-6-50 bordeaux mixture (see page 23)	Necessary only in case these diseases are present. Cover all leaves and bud clusters. If rose chafers are eating buds, add 2 lb. of arsenate of lead and 1 gal. of molasses to 50 gal. of spray
PETAL-FALL (Immediately after blossoming) 3 to 5 days after the fall of the bloom.	Berry moth Mildew Black rot	2-3-50 bordeaux mixture Arsenate of lead 1½ lb. and *Resin fish-oil soap 1 lb. or *Fish-oil ½ pint Water to make 50 gal.	Very important where berry moth is serious. Dissolve the soap in hot water and add to bordeaux while agitator is going. If rose chafers are present, increase the poison and add molasses as given in pre-blossom spray
REPEAT 7 to 10 days after petal-fall spray	Berry moth Root worm Black rot	Same as for petal-fall spray	Very necessary where berry moth is serious. Be sure to cover fruit clusters. If young leafhoppers are numerous on the under sides of the leaves, add ⅓ pint of nicotine sulfate and, with high pressure, force the spray against under sides of leaves
SPECIAL LEAF-HOPPER (In July before the first leafhoppers develop wings)	Leafhopper	Same as petal-fall spray, except that ⅓ pint of nicotine sulfate is substituted for arsenate of lead†	This special spray is sometimes necessary in order to control leafhoppers and prevent "rusty" foliage. Direct against insects as advised in previous spray

*One of these materials is necessary as a spreader in this and the later sprays. Laundry soap can be substituted but is more difficult to dissolve.

†Arsenate of lead should not be applied later than the "Repeat Spray" because of the residue remaining on the harvested fruit.

FACTS ABOUT SPRAYING GRAPES

It is impossible to construct a spray schedule for grapes that will have general application. The insect and disease problems of vineyards located in different communities and even in vineyards of the same community are frequently quite variable. For example, grape mildew, while a serious disease on the Lake Erie Islands and at the west end of Lake Erie, is rarely a serious problem in the commercial grape belt east of Cleveland. Rose chafer usually is troublesome only in vineyards with sandy soil. Nearly all grape insects are quite localized in their distribution even within the same vineyard. In many commercial vineyards of recent plantings and in some home plantings, excellent grapes are being grown without any sprays. In other plantings one or, at the most,

two applications of spray will control the troubles present. In only a few vineyards will the full schedule of sprays be needed.

Each grower should study his conditions and apply only such sprays as are found necessary. Thoroughness is very essential; berry moth and leafhoppers cannot be controlled, except by very thorough applications. In the after-bloom sprays from 125 to 150 gallons of spray material per acre are necessary in the average vineyard.

During most years arsenate of lead cannot safely be applied to grapes after the first week of July, because of the spray residue that will be carried by the harvested fruit.

INFORMATION ABOUT SPRAY MATERIALS

SPRAYS FOR DORMANT USE

OILS

The principal field of usefulness for dormant applications of oil in Ohio is in the control of scale insects and the European red mite. In northern Ohio the European red mite has gradually increased in numbers in many orchards. Since oils are very successful in destroying the overwintering eggs of this pest, the trend has turned to the use of these materials for the dormant period.

The oils available are of two general classes: (a) the so-called miscible oils and (b) oil emulsions. In either case, the commercial product readily mixes with water. It does not irritate the eyes and exposed parts of the body of the operator. It spreads well on the tree, and, because of its tendency to lubricate rather than corrode, it works well in spraying machinery.

In the various commercial products there is considerable variation in the nature of the oil used and in the method of rendering the oil miscible in water. It naturally follows, therefore, that the rate of dilution of the several commercial brands of spray oil varies considerably. This ranges from 3 to 6⅔ gallons to make 100 gallons of spray. In using any one of the commercial brands of spray oil, the directions supplied by the manufacturer should be followed.

The principal precautions to be observed in using oil sprays are: First, follow the proper procedure in diluting oils for spraying. Do not pour the undiluted oil directly into the partly filled spray tank, but add a little water to it and stir vigorously before pouring it into the sprayer. Second, make certain that the oil and water mix well. Failure to mix may be due to the stock material having "broken". The principal cause of "breaking" is freezing

weather. Some spray oils will tolerate very low temperatures; others will not. Third, do not apply dormant oils when the temperature is below 40° or when low temperatures are forecast. Oil applied under such conditions may cause serious damage to the trees. Fourth, spraying with dormant strength oils may cause damage if the application is made after buds show green. It is not recommended that oil sprays be applied during the delayed dormant period and it is particularly dangerous to use oils during the delayed dormant period if the temperature is unseasonably high. During some seasons and with some oils delayed dormant applications may result in little or no damage while on other occasions the crop loss may be severe.

Fig. 5.—Branches showing effect of a 6 per cent dormant oil spray applied when buds were breaking; also unsprayed branches, as check

Spring applications of oil sprays are favored over fall applications. Both scale and red mite are more effectively controlled by spring spraying. If the spraying is done while apple buds are swelling, better results will follow than if the work is done when the tree is fully dormant. Peaches may be seriously injured if a dormant oil is applied while the buds are breaking.

The preparation of home-made oil emulsion.—Some growers prefer to make their own dormant oil emulsions. If this is done, it is important that the proper oil be secured; under no circumstances

should motor oil or waste oil from automobile crankcases be used. Lubricating oil of the following specifications is recommended. This can be furnished by many oil companies.

Viscosity—from 90 to 250 seconds at 100° F. (Saybolt)
Volatility—less than 2 per cent
Specific gravity—from 0.88 to 0.91 at 68° F.

In preparing the oil emulsion any one of the three following formulae may be used. If the product is to be stored for some time before using, Formula No. I is recommended, but it should be remembered that the stock emulsion should be protected from freezing weather after it is prepared.

FORMULA No. I

Lubricating oil (see specifications)	2 gal.
Water (soft)	1 gal.
Potash fish-oil soap	2 lb.

The ingredients are mixed in a vessel and are heated until they start to boil. The vessel is removed from the fire and the mixture pumped twice through a spray nozzle at a pressure of over 100 pounds.

Ordinarily, 3 gallons of the emulsion prepared by Formula I used in 100 gallons of water are of sufficient strength, but, in instances of very severe infestations of scale or red mite, 4½ gallons to 100 gallons of water should be used.

FORMULA No. II

Lubricating oil (see specifications)	2 gal.
Water	1 gal.
Calcium caseinate	¼ lb.

In preparing this formula, sift calcium caseinate into the water while stirring briskly until the amount specified has been added. Mix together the oil and calcium caseinate solution and pump twice through the spray nozzle at a pressure to exceed 100 pounds.

This emulsion should be used at the strength recommended for Formula No. I.

FORMULA No. III

Lubricating oil (see specifications)	2 gal.
Water	1 gal.
Copper sulfate	¼ lb.
Hydrated lime	½ lb.

Dissolve the copper sulfate in one-half the water and add the solution to the oil. Next mix the lime with the remainder of the water and add this to the oil-copper sulfate mixture. Pump twice

through the spray nozzle at a pressure to exceed 100 pounds. The copper sulfate and lime in this mixture are emulsifiers and have little fungicidal value.

Any of these three formulae, as given, will make a spray containing 2 per cent oil when diluted to 100 gallons in the spray tank. If a spray of this strength is desired and the tank holds 300 gallons, three times the quantity of each material in the formula should be used. If a 3 per cent oil spray is needed and a 300-gallon tank is used, multiply each material by 4½ to obtain the required amount.

Any of the preceding oil formulae may be combined with 2-4-50 bordeaux mixture for use on peaches. To do this, make the bordeaux mixture as explained under that heading (page 23). When the spray tank is three-fourths full of the bordeaux, add the proper amount of stock oil emulsion while the agitator is running and then fill the tank with water.

Tank mixing of oil sprays.—While Formulae II and III may be stored for future use, it has generally been found that these two mixtures can be used to better advantage by mixing each tankful separately and applying immediately to the trees. With Formula II this is done as follows: Place into the tank about 3 gallons of water for each hundred-gallon capacity of the tank. More or less water may be used, but in any case it should cover the suction outlet. With the agitator running, slowly sift in the amount of calcium caseinate required for the tank. When this is in solution, pour in the oil (2 gallons for each 100-gallon capacity of the tank) and pump through a nozzle back into the tank until the whole mixture appears without a trace of free oil. Water to fill the tank is then added and spraying should start as soon as possible.

Tank mixing with Formula II avoids the curdling of the stock emulsion that usually occurs when this is stored even for a few days.

With Formula III, the copper sulfate, dissolved in half of the water specified, is placed in the tank and the lime in the other half of the water is added with agitator running. For a 200-gallon tank, a gallon or more of water for each material in solution should be used, or enough to cover the suction outlet. The oil is then added and pumped as for Formula II, after which the tank is filled with water.

LIME-SULFUR

Previous to the introduction of oils, lime-sulfur was universally used for dormant spraying in Ohio. Where either concentrated liquid lime-sulfur, at a dilution of 1 to 7, or dry lime-sulfur of the recommended strength has been applied very thoroughly, scale

insects have been controlled. In orchards where red mites have been serious, lime-sulfurs have not controlled this pest. Lime-sulfur is safer to use in the delayed dormant period than are the oil sprays, because it rarely gives serious burning of leaves or blossom buds. The chief objection to the use of dormant strength lime-sulfur is its irritation to the eyes and exposed parts of the body of the spray operator.

For the control of peach leaf curl there is no spray superior to lime-sulfur if applied when the trees are dormant. If scale is not a problem, lime-sulfur can be used on peaches at one-half the strength recommended for the control of scale insects.

In preparing dry lime-sulfur for spraying, it is advisable to stir the required amount of powder in a small quantity of water before adding to the spray tank. Dry lime-sulfur can be held over from one year to another without deterioration. Liquid lime-sulfur, when held over winter, should be stored where it will not freeze and sealed to exclude the air. The freezing point of concentrated liquid lime-sulfur is much below the freezing point of water. If the material has been allowed to freeze it should be tested with a Baumé hydrometer before using. More detailed information about the properties of lime-sulfur and other sulfur compounds is given on the following pages under the heading of "Sulfur Fungicides."

SPRAYS FOR SUMMER USE

SULFUR FUNGICIDES

Sulfur fungicides can be grouped into two rather specific types or classes; namely, (1) combined sulfur, as calcium, sodium, or potassium sulfides and (2) uncombined sulfur, such as occurs in the wettable sulfur mixtures. In Type 1, the sulfur is rendered soluble by a definite chemical reaction in which complex sulfides are formed. The sulfides are very caustic, highly fungicidal, but very unstable when exposed to the air. When sprayed on a tree they break down to form elemental sulfur; this ensures the lasting effectiveness of the spray. In general, they are apt to cause more or less injury to most types of foliage and should not be used at all on such tender foliage as peach, plum, and sweet cherry.

Type 2, comprising uncombined sulfur, is prepared as a mechanical mixture in which the sulfur remains insoluble. This type is less effective as a fungicide but causes practically no injury on any type of foliage that tolerates sulfur.

LIME-SULFUR

Lime-sulfur is the most important member of the sulfide group. Practically all commercial brands of the concentrated form are of equal value, provided the Baumé reading is 32-33°. A lime-sulfur having a 33° Baumé reading contains 2.7 pounds of sulfur to a gallon of the concentrate. The sulfur is mostly in the form of penta-sulfides (a maximum combination of sulfur with lime), in which form it is most effective as a fungicide. Lime-sulfurs with lower Baumé readings (which frequently occur in home-made lime-sulfur preparations) are less effective in controlling disease and, when combined with arsenicals, are apt to cause injury to foliage.[2]

Liquid lime-sulfur has been the standard spray material for apples for many years. Recently, however, rather severe losses have resulted from its use. Foliage is frequently burned and the set of fruit often reduced. This injury is further increased when lime-sulfur is combined with arsenate of lead. At present, liquid lime-sulfur should be used with caution for summer spraying and should be replaced by safer materials whenever possible. There are a few reliable substitutes, one of which is dry lime-sulfur.

DRY LIME-SULFUR

For greater convenience in handling, shipping, and storing, manufacturers have devised powdered forms of lime-sulfur. Powdered or dry lime-sulfur contains the same ingredients as liquid lime-sulfur, and, in addition, a stabilizer, making its manufacture possible. Chemically, 4 pounds of dry lime-sulfur are equivalent in sulfide content to 1 gallon of liquid lime-sulfur concentrate. In practice, the dry form has proven to be slightly more effective in disease control and causes less injury than an equal concentration of the liquid. Apparently, in the drying process or because of the effect of the stabilizer, the sulfides are rendered less toxic to foliage and the subsequent deposit of sulfur is in a more finely divided form.

Since dry lime-sulfur is safer and yet equally as effective as liquid lime-sulfur, it is preferred for summer sprays on apples.

OTHER SULFIDES OF SULFUR

These are compounds similar to lime-sulfur, except that sodium or potassium is combined with sulfur instead of lime. They are usually sold on the market under trade names, and two of the more generally used are Soluble Sulfur Compound and Sulfocide. A note

[2]Those wishing to prepare their own lime-sulfur will be furnished directions upon request.

of warning must be sounded against combining these sulfides with arsenate of lead for summer spraying. Such a combination may result in releasing free arsenic, followed with serious burning of the foliage and even defoliation. When such proprietary compounds are used, the manufacturers' recommendations should be followed.

THE WETTABLE SULFUR SPRAYS

Sulfur alone cannot be used to make a spray, because water will not wet it. When sulfur is mixed with water, most of the sulfur collects in a mass at the surface, and no amount of agitation will separate it sufficiently for uniform distribution in the spray. This difficulty has been overcome by the use of various seasoning or wetting agents. Mixtures of lime and calcium caseinate or lime and glue are the more common wetting agents, though such mixtures reduce the fungicidal action of the sulfur. Many manufacturers have developed other types of wetting agents and are producing excellent wettable sulfurs.

Wettable sulfur sprays are practically non-caustic and rarely cause injury to foliage and little impairment in finish to fruit. They are compatible with arsenate of lead, and there is usually no increase in water soluble arsenic in such mixtures. While they are ideal from the standpoint of safety, many of them lack efficiency in control, especially of such apple diseases as Brooks spot, blotch, and bitter rot. In sections where these diseases do not occur, some of the better wettable sulfur sprays will give control of apple scab during the post-bloom period.

Growers will do well to study their conditions, and, when apple scab is not serious or has been held in check by the pre-blossom sprays, they may substitute a good wettable sulfur in the late sprays. A description of some of the better known wettable sulfur sprays follows. Very little, if any, lime should be used with these sprays on apples.

Flotation sulfur.—One of the most effective wettable sulfur sprays for the control of apple scab is known as flotation sulfur. It is made from a by-product in the manufacture of artificial gas. It is colloidal in nature, contains a trace of insoluble materials, suspends well in water, and is sold on the market in both paste and dry form. Results from three seasons' experiments indicate that the paste form can be depended upon for the control of apple scab during the post-bloom period. In more limited trials the powdered form has been slightly less effective.

The following spray formula is recommended: Beginning with petal-fall spray for apples, pears, and sour cherries, as a substitute for lime-sulfur, use 10 pounds of paste, or 8 pounds of

powder, in 100 gallons of water. For peaches and sweet cherries use 6 pounds of paste, or 5 pounds of powder, in 100 gallons of water.

Colloidal sulfur.—This is a comparatively new product in which the sulfur is in a very finely divided state, forming a true colloidal mixture. Various theories state that sulfur is toxic only after it is changed to minute particles, a vapor, a gas, or an acid. This product contains properties that theoretically should make it an ideal fungicide. One season's trials indicate that it can be substituted for lime-sulfur throughout the season. It caused no injury to foliage, and the fruit sprayed with it had excellent finish. It is compatible with arsenate of lead and some summer oils.

For apples, pears, and sour cherries, use 4 pounds of the paste to 100 gallons of water, as a substitute for lime-sulfur. For peaches and sweet cherries use 2 pounds of the paste to 100 gallons of water.

Other wettable sulfur sprays.—Mist Brand sulfur is a proprietary compound found satisfactory for the control of peach diseases and for apple scab during the post-blossom period. For apples it should be used at the rate of 12 pounds to 100 gallons of water, and 8 pounds to 100 gallons for peaches and sweet cherries.

Dritomic sulfur, Mulsoid sulfur, and Sulfuron are proprietary mixtures and are sold primarily for use on peaches. They can be relied upon for control when used according to manufacturers' recommendations.

SULFUR-LIME DRY MIX

This is primarily a peach spray. It is sold on the market under a variety of names, such as New Jersey Dry Mix, Peach Mix, Dry Mix, and Sulfur-lime Dry Mix. The grower can prepare his own by mixing, dry, a fine grade of sulfur (300 mesh), 12 pounds; high calcium freshly hydrated lime, 6 pounds; and calcium caseinate (Kayso), 4 ounces. This mixture is sufficient for making 100 gallons of spray. Using these proportions, the season's supply may be mixed before spraying operations begin. Old material, whether home or factory made, is apt to be unsatisfactory.

While this mixture is safe on almost all types of fruit foliage, it is not effective in controlling apple scab, even in late sprays.

BORDEAUX MIXTURE

The old standard bordeaux mixtures were prepared with equal weights of copper sulfate and stone (lump) lime. Because of copper injury to foliage and fruit, this formula has been changed to include a greater percentage of lime. It has also been found that

equally as good bordeaux mixtures can be made with a special, fine, hydrated spray lime, which is now on the market, as with the stone lime. Hydrated lime is usually more accessible and much less troublesome to use. In all recommendations included in this bulletin, a good grade of freshly hydrated lime is specified. A mixture made from 2 pounds of copper sulfate and 4 pounds of hydrated lime to 50 gallons of water is designated by the formula 2-4-50. The proportions are changed according to strength desired.

There are two general methods now in use for preparing bordeaux mixture. The standard method (Method I.) is as follows:

Method I.—Prepare a stock solution of copper sulfate by dissolving the required amount of copper sulfate in the ratio of 1 pound to 1 gallon of water. To do this always suspend the copper sulfate crystals in a sack submerged just beneath the surface of the water. The warmer the water, the more rapidly the crystals will dissolve, but they will dissolve in moderately cold water in a few hours.

The stock hydrated lime is prepared by making a lime paste of known strength which can be washed into the tank through a screen. If a good grade of freshly hydrated lime is available it may be sifted directly into the tank.

To fill a 100-gallon tank with a 2-4-50 bordeaux mixture, fill the tank two-thirds full of water and start the engine to keep the agitator running. Mix the 8 pounds of hydrated lime into a cream and pour through a strainer into the tank; *when thoroughly mixed,* add the 4 gallons of copper sulfate stock solution. Complete the filling of the tank to 100 gallons. If arsenate of lead is to be used it should be added last.

Method II.—The second method is the preparation of *instant bordeaux mixture.* Recently, copper sulfate has been manufactured in what is known as snow form, which dissolves quickly. No stock solution, therefore, is necessary. The mixture is made as follows: Fill the tank half full with water and, with the agitator running, wash in the hydrated lime through the screen. Next, fill the tank two-thirds to three-fourths full, place the copper sulfate snow on the screen and wash through, and then completely fill the tank. This method is the simplest for making bordeaux but has not been thoroughly satisfactory. If the copper sulfate snow, or powder, does not dissolve properly, a lumpy bordeaux is made, and nozzle trouble follows.

Bordeaux mixture is not recommended for use in apple orchards in the northern half of Ohio. While it will control scab, it is likely to cause severe injury, especially during cool, damp

weather. In the southern part of the State, it is recommended for the control of Brooks spot and bitter rot and for use on varieties particularly susceptible to blotch.

NICOTINE SPRAYS

Nicotine is the most suitable poison to use against aphids, leafhoppers, and red bugs infesting fruit trees. Nicotine sulfate is the form in which it is purchased. This will combine safely with all of our insecticides and fungicides used in the orchard, although it adds considerably to the expense of these sprays. Nicotine sprays must strike the bodies of insects to kill them and have very little insecticidal value, except at the time of application. It is useless to apply nicotine for aphids unless the insects are exposed, so that they can be covered with the spray.

When nicotine sulfate is combined with a ¾ per cent oil, the spray has given rather good results in experimental tests against green aphis when applied after the aphis colonies appear on the foliage; however, it cannot be depended upon for controlling green aphis when conditions are favorable for the insect's development. The grower should study his orchard and decide for himself whether the losses from these insects are likely to prove more costly than the use of nicotine spray.

For detailed information concerning different species of apple aphids and methods of control consult Ohio Experiment Station Bulletin 464.

ARSENATE OF LEAD

Arsenate of lead is the most extensively used stomach poison for controlling codling moth and other chewing insects in the orchard. Unless otherwise stated, the term "arsenate of lead" in this bulletin refers to the dry form. Dry arsenate of lead does not deteriorate with age. It should contain at least 30 per cent of arsenic pentoxide and not over three-fourths of 1 per cent of water-soluble arsenic. The manufacture of arsenate of lead is well standardized and there is little danger of getting an inferior product.

Arsenate of lead has good physical properties for spraying and does not dissolve but is held in suspension in water. It can be combined with fungicides, such as lime-sulfur or bordeaux mixture, in making a combination spray. Arsenate of lead adheres well as a spray; this quality increases its effectiveness against insects but prevents its being ideal for the purpose intended because of the residue present on harvested fruit. Though many tests have been made with substitute materials, it still takes front rank in the degree of insect control secured in the orchard.

Arsenate of lead is best prepared by mixing with a small amount of water before placing in the spray tank. This "milk" of arsenate of lead is poured into the tank last, while the agitator is going, preventing it from settling to the bottom of the tank. From 2 to 3 pounds are used in each 100 gallons of spray. On peach foliage and in the summer applications on apple, 8 pounds of good hydrated lime are added to each 100 gallons of spray to reduce the danger of arsenical injury.

ARSENICAL SUBSTITUTES

When the problem of arsenical residue came into the foreground there developed an immediate interest in arsenical substitutes. It would be useless to list the materials that have been tried in the hope that they might replace arsenate of lead, since almost all of these have been failures. Only those that have given some encouraging results and have been rather widely tested will be discussed.

SUMMER OILS

It is probable that these come as close to being an acceptable substitute as any on the market today. Their effectiveness is greatest when used as an occasional application rather than when used alone throughout the season. The principal objection to them is their cost. They are fully discussed under "Oil Sprays for Summer Use," on page 27.

OIL AND ARSENATE OF LEAD

This combination is very effective in the control of codling moth and other insects. However, it presents difficulties in its combination with a suitable fungicide, and the arsenate is so firmly fixed on the fruit that the residue problem is greatly increased.

OILS AND NICOTINE

When used together under dry conditions oil and nicotine are quite effective in midsummer sprays. However, the cost is excessive and in Ohio about the same result is obtained by oil alone.

THE FLUOSILICATES

These materials, in different forms, have been tested quite widely for control of fruit insects. At present it appears that the most promising of these is barium fluosilicate. Even this material, because of its lack of adherence, has failed to control codling moth when used alone throughout the season. When substituted for arsenate of lead in the midsummer spray, it has given only fair control but has reduced the residue problem.

OIL SPRAYS FOR SUMMER USE

The use of summer oil sprays in the Pacific Northwest has raised the question as to their value in Ohio. Data taken in numerous experiments show that, at present, there is no need for their general use in this State. However, in certain instances summer oils may be used to advantage and the following facts concerning them are given for interested individuals.

Only highly refined oils manufactured expressly for summer spraying should be used. All oils commonly used in the dormant season are likely to injure foliage because of the active chemicals they still contain, these having been removed from the summer oils by refining. Practically all companies selling summer oils have tested their products, particularly with regard to injury, and the recommended strengths should be followed.

For the past 5 years the Ohio Experiment Station has tested different commercial summer oils against the codling moth, although notes have been taken on other pests, such as scales of different species, leafhoppers, aphids, and mites. These oils have given a measure of control for codling moth approaching that obtained by using arsenate of lead. The majority of tests, however, favor the arsenate by varying margins. With oils against other insects, no striking results have been obtained, although slight reductions in scale and mite injury have been noted.

Summer oils have little fungicidal action, and at present a fungicide must be applied separately if diseases are to be controlled. Due to the prevalence of fungous diseases in Ohio, it would seem that the general use of oils would demand fungicides that could safely be used with them. The use of summer oils, for this reason, is limited.

The main point favoring the use of summer oils is that arsenical residue is greatly reduced and, in some instances, the fruit has a better finish. However, in regard to safety of foliage, the oils are not altogether reliable, as was shown during the season of 1930.

SUGGESTIONS CONCERNING SPRAY PRACTICES

PROTECTING THE FRUIT

THE PROBLEM OF SPRAY RESIDUE

Spraying for codling moth control sometimes results in the fruit carrying too much residue. The world and domestic tolerance for amount of arsenic residue permitted by law is .01 grain of

arsenic trioxide (As_2O_3) per pound of fruit. When the amount present exceeds this, federal and state food and drug officials have authority to compel the removal of the same or they may confiscate and destroy the fruit.

Ohio apple growers who follow a minimum schedule of three after-blossom sprays rarely have a serious residue problem if the last two sprays are timed to coincide with the beginning of hatching of the two broods of codling moths. The last spray is usually made during July or early August, which is fully 8 weeks before the harvest of winter varieties of apples. Growers who find it necessary to apply extra cover sprays during the summer in order to control codling moth or to apply the last spray less than 6 weeks previous to harvest can expect to have a spray residue problem.

In parts of southern Ohio where the control of codling moth requires extra cover sprays in the summer, some growers have found it necessary to install washing machines to remove this residue. These machines are rapidly becoming recognized as efficient and desirable acquisitions in the preparation of fruit for market. The apples are washed with a 1 to 3 per cent hydrochloric acid solution, followed by rinsing with clear water to remove the acid. This removes leafhopper and aphis stains as well as spray residue.

Wiping the fruit has been resorted to in an effort to remove arsenical residue, but the best that can be expected from this method is to remove approximately one-third of the arsenic originally present.

Successful washers have not yet appeared on the market for the removal of residue from grapes that have been sprayed for the control of berry moth. Until such washers have been developed, the grape spray schedule will of necessity have to be curtailed to enable the harvested fruit to be marketed with the least possible residue.

SPRAY AND WEATHER INJURY

Spray and weather injury may be very similar in appearance. Spray injury develops when improper materials have been used or when the right materials have been applied the wrong way. Weather injury results from exposure to extremes of temperatures and moisture. Varieties vary greatly in their susceptibility to spray and weather injuries (page 10).

Trees lacking vigor are frequently injured by spray and weather influences under conditions where vigorous trees would not so easily be affected. Similarly, foliage that has been previously injured by insects, diseases, hail, or wind whipping is more susceptible to spray injury than healthy foliage. Accordingly, orchards which are maintained in a healthy condition are less apt to be injured by spray materials or adverse weather conditions.

BORDEAUX INJURY

Bordeaux mixture as a spray material for apples may injure the fruit in the form of russetting. Varieties such as Grimes, Golden Delicious, Jonathan, Baldwin, Ben Davis, Gano, and Ensee are very susceptible to russet injury. Other varieties such as Rome, Gallia Beauty, Delicious, Northwestern Greening, Duchess, and Wealthy are comparatively resistant to russet injury. Applications of bordeaux in pre-blossom and petal-fall sprays cause the most russetting and some risk continues until about 6 weeks after petal fall. Bordeaux injury is increased by cool, wet weather and high relative humidity. The safest time to spray is when trees are dry and the weather favors quick drying of the spray material on the trees.

Fig. 6.—Russet of fruit caused by bordeaux spray

Bordeaux injures apple foliage by causing yellowing of the leaves and, in some cases, premature defoliation. This injury is reduced by using a weak bordeaux, such as 1-3-50. Stronger bordeaux should not be used unless needed for control of such diseases as bitter rot.

LIME-SULFUR INJURY

Lime-sulfur will burn both foliage and fruit of apples if the spray is applied in very hot weather or in strong concentrations. It burns the edge of apple leaves where the material accumulates. Liquid lime-sulfur often causes dwarfing and crimping of apple leaves in the early stages of their development. This affects the proper growth of the fruit and impairs finish and quality. Frequently, the extent of this injury can be noticed only when there is an actual basis of comparison as occurs in spraying plots where different materials are used in the same orchard. Foliage dwarfing and crimping also come from low temperatures in early stages of leaf development. This is very similar to lime-sulfur injury and is often confused with it.

Lime-sulfur may also burn the fruit during extremely hot weather, when applied in strong concentrations and heavy dosages. Spraying whenever the temperature is above 85° Fahrenheit or when the relative humidity is very high is associated with risks from burning.

The prevention and reduction of lime-sulfur injury can best be secured by substituting dry lime-sulfur for liquid lime-sulfur and by adding an excess of lime in the mixture as recommended in the spray program.

Lime-sulfur, either liquid or dry, is not safe for the summer spraying of peach trees. Materials less likely to burn are recommended in the peach spray program, page 12.

ARSENICAL INJURY

Peaches are very susceptible to arsenical injury when arsenate of lead is used alone or combined with sulfur fungicides that do not contain sufficient fresh, high calcium hydrated lime in the mixture. The leaves are damaged in two ways: (1) They may show many small injured areas, giving a "shot hole" appearance or (2) they may yellow and drop prematurely, or both. Frequently, tender, growing peach twigs are injured in spots where the spray material has accumulated and, as the wood ages, scaly bark may develop from this injury. While the fruit is not often directly injured, the damage to foliage may so seriously reduce the manufacture of food that the fruit will be small, of poor color and quality, and may drop prematurely.

To prevent arsenical injury on peaches, use the minimum number of arsenate of lead applications and not more arsenate of

lead than recommended in the Peach Spray Program. One application of arsenate of lead combined with excess lime, as recommended in the shuck-fall spray, is sufficient for curculio control in most orchards. When arsenate of lead is used with commercial wettable sulfurs, add 4 pounds of fresh, high calcium hydrated spray lime to each 100 gallons of spray. Unless freshly made, dry mix is unsafe to use with arsenate of lead.

Apple foliage and fruit may be injured by arsenical sprays. The damage to the foliage may be manifest in two ways. The first and more noticeable type is marginal foliage burning; this probably is the result of heavy concentrations of spray materials which collect at the tips and margins of leaves. The second type of injury is a general yellowing of the foliage which may be caused by the absorption of the arsenic by the leaf or by injury to the petiole. In extreme cases of burning, the damage may amount to almost total defoliation. The shedding of blossoms and newly set fruits, which in some instances has been serious, is another form of injury from lime, arsenate of lead sprays. Arsenical injury to the fruit is usually expressed by a blackened area around the calyx end, which later becomes sunken. Secondary rot infections may follow such injuries.

Arsenical burning on apples is largely prevented by the addition of excess lime to the arsenate of lead and lime-sulfur combination. While present evidence indicates that excess lime tends to decrease the efficiency of both the fungicide and the arsenical, the finish of the fruit produced when excess lime is added is superior to that produced when the lime is omitted.

MECHANICAL INJURIES

Mechanical injury to the foliage and fruit comes from the improper use of spray equipment, poor break-up of the liquid, coarse particles in the spray material, and drenching of the foliage. It appears in the form of russetted fruit, dwarfed or torn leaves, and, in part, accounts for the lack of finish and quality of the fruit in many orchards. Prevention of these injuries may be secured by following the recommended spraying methods.

WEATHER INJURY

Weather injury to fruit and foliage is often confused with spray injury. Low temperatures and frosts during the blossoming period and early part of the growing season cause varying amounts and kinds of russet injury. Often this injury takes the form of a belt of russet around the apple.

Leaves may be injured by frost so that dwarfing and crimping develop and, when severely injured, blisters may develop on the under surfaces. Leaves so injured often turn yellow and drop prematurely.

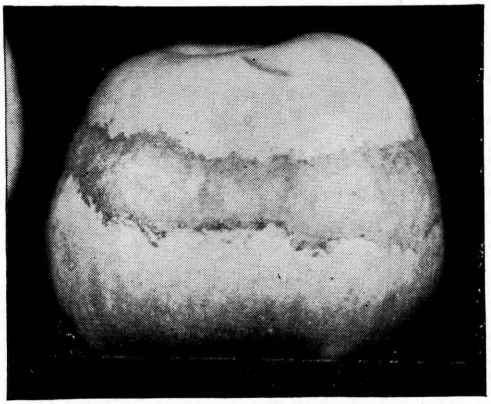


Fig. 7.—Russet ring caused by frost

Extremely hot weather sometimes causes sunburn on the fruit. This is manifested by a discoloration and, in extreme cases, by a blistering and cracking of the skin on the exposed area. Very hot weather may also cause a bronzing of the red tones and a whitening of the green color tones of the fruit.

USE OF PROPER LIME IMPORTANT IN PREVENTING SPRAY INJURY

The chief use of lime in the summer sprays is to prevent spray injury. There are several common forms of lime on the market and, therefore, fruit growers should use care in purchasing the proper compound. When limestone is burned, the product produced is burned lime (CaO), sometimes called lump, stone, or quick lime. If water is added to burned lime, hydrated lime is formed. If hydrated lime is exposed to the air, air-slaked lime, or calcium carbonate, is formed. This last product is very inactive and is not suitable for spraying purposes. Hydrated lime is recommended for spraying. Good hydrated lime has several characteristics which the grower should investigate before buying: First, it should be free from grit and so finely divided that 99 per cent of the particles will pass through a 300-mesh sieve; all should pass through a 200-mesh. Second, the lime should be a high calcium lime and not a high magnesium lime. High calcium limes contain less than 1 per cent of magnesium. Third, the lime should be freshly hydrated before it is shipped. Lime kept over from one season to the next should not be used for spraying purposes. Such lime may be profitably added to the soil. A supply of lime purchased in the spring will be satisfactory for that season.

USE OF SPREADERS

Extensive data taken in many experiments show that very little is gained by the use of spreaders in tree sprays. Spreaders usually make the sprayed tree look somewhat better in that the spray coat is more even. They are reported to make a given amount of spray cover more trees, but this gain is usually offset by the additional cost of the spreader. In almost all instances spreaders are not to be recommended, except for grapes, where either a soap or fish-oil spreader has proven valuable in the control of berry moth.

AMOUNTS OF SPRAY SOLUTION REQUIRED FOR ADEQUATE COVERAGE

The amount of spray solution required to spray a tree of a given size properly depends upon a number of variable factors, such as type of gun or nozzle, volume and pressure developed by the spray pump, velocity and direction of the wind, type of pruning practiced, the nature and abundance of diseases and insects, but, more than anything else, upon the judgment of the individual operating the rod or gun. To spray until a tree drips is not a safe guide to follow. Such a rule may lead to wastefulness but more often to inadequate spraying of a tree.

Records of spray solution required in the Experiment Station orchards at Wooster have been kept over a period of several years. During this time the spraying was done under the direction of the same man. The sprayer used was of moderate capacity, maintained a pressure of 375 pounds, and operated two spray guns of the ordinary type. In these orchards trees less than 12 years of age were pruned in such a manner as to leave them moderately dense, while the trees of full bearing age were more heavily pruned.

TABLE 8.—Amounts of Spray Solution Applied per Tree (Wooster)

Age of trees	Average amount per application	
	Apples	Peaches
	Gal.	*Gal.*
2 to 3 years	0.4	0.7
5 years	1.2	3.0
10 years	5.5	5.4
12 years	8.0	.....
15 to 20 years	10 to 14	.....
21 to 35 years	15 to 24	.....

The data submitted in Tables 8 and 9 are taken from the spraying records in the Station orchards. The amounts of material per tree used at Wooster have at all times corresponded very closely

with the amounts used in the orchards of the various sub-stations and county experiment farms. The figures given are not intended as arbitrary recommendations to be followed in every case but are suggestive of the amounts found necessary for good results under the conditions previously mentioned.

TABLE 9.—Seasonal Distribution of Spray Solution

Period	Per cent of total for season
Dormant	13
Pre-blossom (1)	15
Pre-blossom (2)	14
Calyx-cup	20
First brood codling moth	19
Midsummer	19

In a program of six sprays per season the proportion of the amount of solution used in the several applications to the total amount used during the season was found to be as shown in Table 9.

ESTIMATE OF MATERIALS FOR SEASON

In ordering materials for any season the first consideration should be to determine as nearly as possible the program to be followed, especially during the early part of the year—the number of sprays, the materials to be used, and the dilution. Then, by using the amounts applied per tree as shown in Table 9, it is relatively easy to calculate the amount of material needed to spray a given number of trees.

DEFINITE PROCEDURE IN SPRAYING

In considering the subject of how to spray a tree, it should be remembered that orchards in this State are situated on land of widely varying topography. It is obvious, therefore, that any system of spray application must be readily adaptable to the lay of the land. The three plans which follow are suggested for convenient, time-saving, and thorough application of sprays.

METHOD ONE

In Figure 8 is outlined the plan of procedure in spraying an orchard of large size, bearing trees situated on land sufficiently level that it may be traversed readily by a modern power sprayer. The spraying outfit and its direction of travel are indicated at *a*, *a* and *b*, *b*. To save space and, at the same time, to simplify the diagram, only one row of trees and a single line of spray hose are represented. The bordering halves of two rows are generally

sprayed simultaneously. This is accomplished by use of an additional line of hose, a second sprayman, and the reversal of service-routes as outlined in the two similar, but not quite identical, sketches *c*, *c*. In detail, the procedure in spraying, as illustrated in Figure 8, is as follows: Taking up his route at the line *d*, the operator enters beneath the branches of the tree at *e* and takes his position at *f* near its base. The workman begins operations at *g*, directing a fine, mist-like spray both outward and upward among the branches. With the trunk of the tree at his back, he gradually

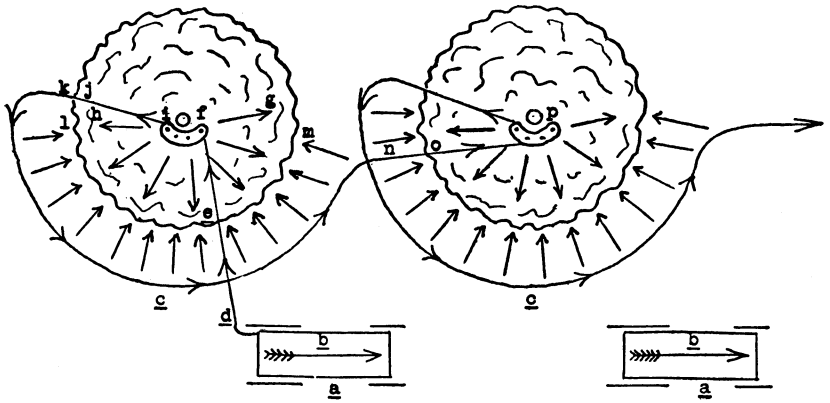


Fig. 8.—The plan of procedure in spraying large-size, bearing trees situated on land sufficiently level to be readily traversed by a modern power sprayer. In spraying such an orchard the bordering halves of the two rows between which the spraying equipment is driven may be sprayed simultaneously.

works toward his right, as indicated by the arrows, until he has sprayed to the point *h* and is standing at *i*. By this time the foliage of the inner half of the tree, except that directly above his head, has reached the "dripping point". He then steps to the position shown at *j*, turns facing the trunk of the tree again, and finishes the tops of the central, upright branches that were directly above his head while he was covering the interior of the tree. Thus, he has done thorough work in spraying the inner half of the tree not readily accessible from outside positions and has avoided the dripping interior of the tree

Emerging from beneath the tree at *k*, he turns to his left, faces the tree again, and begins spraying at *l*. Proceeding along the curving course and carefully spraying the exterior of the tree from the lower to the topmost branches and from all directions, he reaches the point *m*. Here he momentarily ceases spraying and, while the spraying outfit is moving forward to a new position, he

proceeds along the course indicated at *n* and steps beneath branches of the next tree at *o*. Arriving at the point *p*, he proceeds to duplicate the treatment accorded the tree he has just finished. With the adjoining halves of the two rows sprayed at a single passage, the opposite halves are finished as the outfit returns in the succeeding space between rows.

Described in detail, as above, this system of spraying is likely to impress the reader as being somewhat difficult to master and tedious to perform. However, in actual practice, it soon becomes a simple, rapidly progresssing operation.

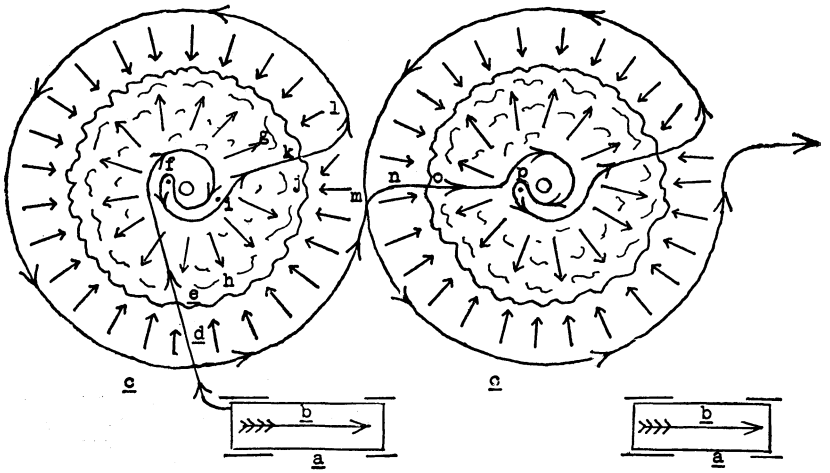


Fig. 9.—A method of procedure in spraying both interiors and exteriors of large, bearing trees, at a single passage of the spraying equipment. By following the service routes outlined in this figure the spray hose never becomes wound about the bases of the trees to cause trouble and delay when the spray equipment and spraymen are ready to move forward.

On steep, stony, or otherwise rough orchard areas, a heavy power spraying outfit can be drawn only with great difficulty by use of team or tractor. Under such conditions one-half of the driving can be eliminated by entirely finishing two rows at a single trip.

METHOD TWO

In Figure 9 is shown the plan providing for thorough covering with spray of both interiors and exteriors of the trees at a single passage of the spraying equipment. The spraying machine and its course are indicated at *a*, *a* and *b*, *b*. The operator of the spray proceeds along the course indicated at *n* and steps beneath the branches of the tree at *e*. Proceeding in a direction as if to pass a few feet to the left of the center of the tree, he turns abruptly to his right and almost completely encircles its trunk.

He takes his initial working station at *f* and begins spraying both outward and upward in the portion of the tree indicated at *g*. Gradually, but without moving to a new position, he turns to his left, thoroughly spraying outward and upward until he has covered about three-quarters of the interior of the tree, or to the point marked by *h*. He then moves to the position indicated by *i*, continues interior coverage spraying to *j*, and moves on to his final working position at *k*. Here he covers the central portion of the tree which, up to this time, has remained unsprayed. He next finishes the previously and purposely uncovered pathway between *j* and *g* through which he passes, practically free from dripping spray, to his first outside position for exterior spraying shown at *l*. From this point he almost encircles the tree as shown by the circular pathway, spraying at every possible angle from lower branches to topmost twigs and finishing at *m*. From this point he crosses over the line *n* to the next tree, walks beneath the branches at *o*, approaches and almost encircles the trunk of the tree, and then stops at his first working point at *p*. From this position there is repeated, as indicated, the program of spraying just completed on the tree immediately preceding.

METHOD THREE

In orchards in which the branches of the trees have been sufficiently thinned by careful pruning and in orchards with younger and smaller trees, spraying from beneath the branches may be omitted. Elimination of this feature of spray application greatly simplifies the work of spraying, as may be seen in Figure 10.

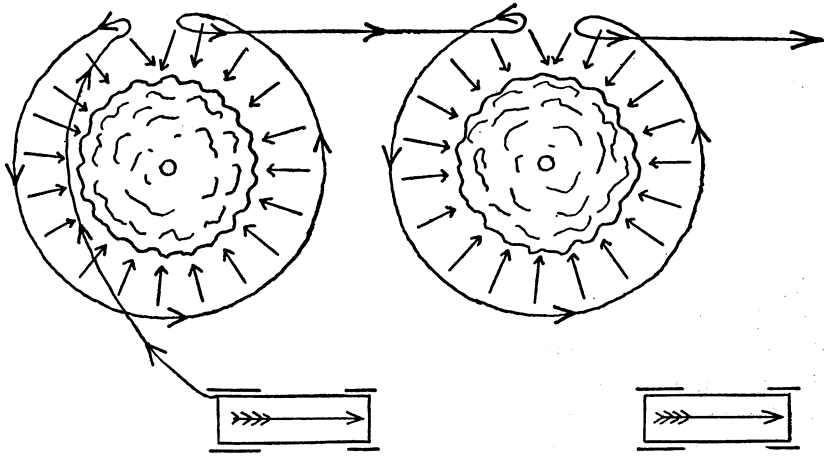


Fig. 10.—In thoroughly pruned orchards and in orchards of younger and smaller trees than are represented in diagrams 1 and 2, spraying from beneath the branches may be safely omitted

Massive, high-pressure spraying machines of great capacity, drawn and operated by heavy tractors with power take-off, are being used now in some of the larger orchards of our State. These machines deliver a large volume of spray through clusters of nozzles and at high velocity. With this equipment the spray is directed by one or more operators from a tower or platform on the spraying machine. The outfit is designed to move slowly, but continuously, between the rows, the spray covering and penetrating the trees from opposite directions. Figure 11 is a diagram showing the course of the tractor-drawn and tractor-driven equipment and the various directions from which the spray reaches the trees. The diagram serves equally well to illustrate the manner in which a modern, high-power dusting machine is used in the orchard.

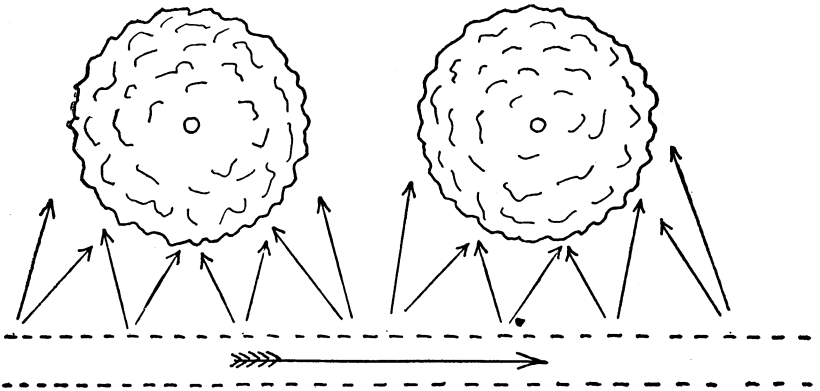


Fig. 11.—This diagram illustrates the manner in which a slowly moving spray machine of great capacity or a modern, high-power dusting machine is used in the orchard

In older orchards the operator should always keep in mind that the most difficult portion of the tree to cover is the top. Too much emphasis cannot be placed on thorough coverage for the top third of old trees.

SPRAY EQUIPMENT

The commercial apple orchard in Ohio should be equipped so that it can be sprayed in 3 days. On this basis, a grower can follow out the recommendations of this bulletin, allow for unfavorable weather, and secure good control. Where the equipment is not large enough to do the work in this time, experience has shown that the best results cannot be secured.

Fruit growers and machinery manufacturers have been steadily increasing the size and volume of spraying equipment used so

that the spray operation consumes less time and labor than formerly. Such a trend is in line with good economy and has enabled the fruit grower to work more efficiently at the spraying job.

SELECTING THE SPRAYER

In determining the kind of sprayer to use, figure out the number of gallons of material that is necessary for one application and then select the machine according to the following table:

Material used for one application	Size pump suitable
Gallons	
Less than 500	Hand pumps
500–3000	Power pump rated up to 10 gallons per minute
3000–6000	Intermediate sized pump, 12–15 gallons per minute
Over 6000	Pumps rated at about 18 gallons or more per minute

EQUIPPING THE MACHINE

The guns, nozzles, rods, and hose to use will depend upon the topography of the orchard, method of spraying, capacity of the pump, and local conditions in each orchard. The spray gun is still preferred by many growers who have orchards on rough, hilly land and find it necessary to spray from the ground. The gun is light, easy to handle, and, when properly used, gives good results. The main objection to the gun is that it is sometimes used so that it delivers a coarse driving spray which causes injury to the foliage and fruit. The spray from the gun should be broken up into a fine mist when it strikes the tree.

The cluster nozzle, recently developed by the Virginia Experiment Station, has been rapidly adopted by many Ohio growers. It is well suited for use where the work is done from a moving sprayer. Where the cluster nozzle is used, the spray is broken into a fine, driving mist which gives excellent uniform coverage and is carried farther than when the gun is used. Where the spray is driven against a high wind, guns are still preferred.

The cluster rod can be used with three or more nozzles where the capacity of the pump and horsepower of the engine are sufficient. The following table gives a good basis for adapting the cluster rod to the pump and sprayer:

No. of rods	No. of nozzles in cluster	Diameter of opening	Pressure in pounds	Approximate pump capacity
1	3	1/12 inch	300	9 gallons per minute
1	4	1/12 inch	350	12 gallons per minute
1 or 2	8	1/12 inch	350	18 gallons per minute

The number of nozzles used in the cluster should be adapted to the horsepower of the engine. With pump of proper size and efficiency about one nozzle can be used to each 1½ horsepower developed by the spray engine. These nozzles may be grouped in clusters of three and four for ground spraying and up to eight where spraying is done from a tank or tower.

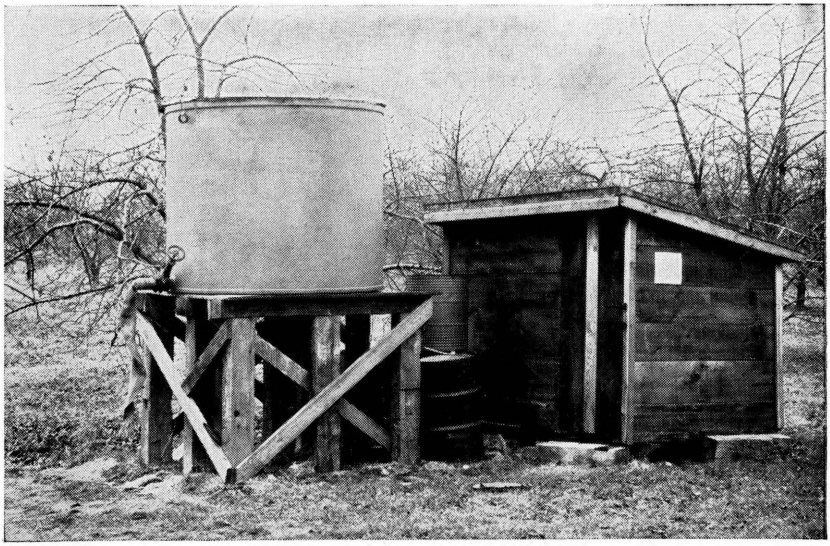


Fig. 12.—Filling station. "Conveniently located filling stations save much time in spraying"

The best grade of rubber spray hose is necessary to withstand the high pressure and rough work of spraying. For ground spraying, use a hose not less than ½ inch in diameter. For tank spraying, a hose ⅝ inch or larger in diameter is desirable. Larger hose allows the freer passage of spray material and does not have the friction loss of a smaller one. The length of the hose for ground spraying should be at least 50 feet. For tank spraying it should be as short as is convenient to handle because the loss from friction decreases in proportion to the length of the hose.

A hose swivel that does not leak is a handy device to add to the hose hook-up. It allows the man who sprays from the ground to turn as he works without twisting and kinking the spray hose.

WATER SUPPLY SYSTEM

A water supply system, set up so that the sprayer can be quickly filled and so that there will be only a short haul, is necessary. Locate supply tanks in the center of each 20-acre block of

orchard. In most cases, the water can be pumped at the source of supply into one tank and piped from there by gravity to supply tanks located at convenient points. All tanks should be set up so that they serve as overhead filling stations with a large, 3- to 4-inch discharge pipe equipped with a gate valve for quickly filling the sprayer. Such an arrangement greatly speeds up the work of spraying and, according to cost records at the Ohio Agricultural Experiment Station, reduces the cost materially.

Where a pond or stream is used as a water supply, a tank filler helps in filling the sprayer quickly. In some cases, supply wagons or trucks are used to haul water from the source of supply to the sprayer. This requires extra teams or trucks, but it is a method which probably enables the grower to secure the most efficient use of his sprayer.

CARE OF THE SPRAYER

The proper care of the sprayer does much to increase its useful life. At the end of each day's spraying, water should be pumped through the spray pump, hose, and nozzles to clean out all chemicals. At the close of the spraying season, the pump, hose, and all equipment should be thoroughly cleaned with water and drained. Then the hose, rods, and guns should be taken off of the sprayer and looked over carefully and any needed repairs made. Nozzles should be cleaned and oiled. The pump should be filled with oil and parts apt to corrode should be cleaned and coated with grease before the rig is put away for the winter.

EQUIPMENT FOR NIGHT SPRAYING

High temperatures and high winds during the day often interfere with proper applications of sprays and dusts. Atmospheric conditions at night are more favorable for this work, especially for dusting, and the rush of spray work may be so great that the equipment is not adequate to cover the orchard in the required time in daylight. To meet any or all of these conditions, floodlights added to the sprayer or duster make it possible to operate at night. The lights commonly used are similar to those that are standard equipment on automobiles, and the electricity is usually supplied by an ordinary storage battery charged with an automobile generator operated by the engine.

Night applications are limited to situations where the operator rides the moving spray tank or duster. Lights are directed on the trees to be sprayed or dusted and on the ground ahead.

STATIONARY SPRAY PLANTS

With stationary spray plants, the spray material is pumped from one central plant through pipes to all parts of the orchard. Only one power plant is needed. The hauling of water and spray materials through the orchard is eliminated and there is less wear and tear on machinery than where portable sprayers are used. Stationary systems are used where the topography is rough or the soil too wet for the use of portable machines or where the system is preferred for other reasons. Some disadvantages of the stationary spray plant are: high cost of installation, the necessity of doing all spraying from the ground, the inability to spray at night, and the interference of pipe lines with other orchard operations. Another objection is that the operator has to drag a longer hose than with any other system of spraying. Further information will be supplied upon request.

DUSTING PROCEDURE

APPLES

Dusting apple orchards to control insects and diseases has met with varying results in Ohio. At the Ohio Experiment Station results have been uniformly good where ten or more dust applications were very thoroughly made. In these tests 25- to 30-year-old trees were given from 2½ to 3⅓ pounds of dust each per application. These tests were carried on during some years of rather heavy scab infection but under light codling moth and curculio infestation.

Dust applications, as we have observed them made by many growers, have been disappointing in the degree of control of insects and diseases. Most Ohio growers who have depended upon dust applications following petal fall have failed to control codling moth in years when this insect was abundant. This is due mainly to the poor adhesive qualities of our present arsenical dusts and to insufficient quantity applied. Some growers use dusts as a supplement to spraying to cover foliage at critical times, when a sprayer cannot be used. When these applications are followed soon with liquid sprays, the results have been good.

Dusting is not effective against scale insects and red mites. To be effective against aphis or red bug, a nicotine dust is necessary. This requires ideal weather conditions while applying, conditions which are rarely attained at the time the control is needed.

Under heavy codling moth infestation, dusting must still be considered as a supplement to spraying to be used when the time is short or water not available for spraying. Under such conditions it should be repeated frequently or followed as soon as possible with a liquid spray that will cover up foliage or fruit with materials which are not easily washed off by rains.

Some Ohio orchards are so situated that dusting appears to be as economical and dependable as spraying. Dust applications will frequently suffice while the orchard is coming into, and during the first years of, production. It is not our desire to discourage anyone who has been successful with dust applications. Where dusting will produce clean fruit as economically as spraying, the grower should make his own choice. The dusts suggested for preblossom applications are: 90-10 manganar (90 parts dusting sulfur and 10 parts manganese arsenate) or 85-15 sulfur-dry lime-sulfur (85 parts dusting sulfur and 15 parts dry lime-sulfur). These are too expensive for the post-blossom period, for which a 90-10 sulfur-lead arsenate dust is suggested.

If a dusting program is followed for control of curculio and codling moth, from five to seven post-blossom applications will be necessary in most seasons.

OTHER FRUITS

Dusting of peaches and plums and sweet cherries for control of brown rot has produced good results and is a method highly recommended where the application is properly timed. An 80-10-10 sulfur-lime-lead arsenate dust is recommended for early applications where curculio control is important. For later applications a 95-5 sulfur-lime mixture is preferred. Dusting of grapes has very limited application and thus far is recommended only for leafhopper control where a nicotine spray cannot be applied. Dusting for the prevention of grape root worm and berry moth injury has not proved satisfactory.

The amount of dust required to cover a tree properly is influenced by the same factors which determine the amount of spray solution needed. However, air currents affect the amounts of dust required for good coverage to a much greater extent than is true of spraying. In the Experiment Station orchards at Wooster, apple trees 8 to 10 years old required from 1 to 1.3 pounds, and trees 25 to 30 years old from 2.5 to 3.3 pounds of dust each per application.

DUSTERS

While dusting has its limitations, the practice has been developed to such an extent that a duster is a valuable piece of supplementary equipment for the commercial orchardist. For young orchards, hand dusters can sometimes be used to advantage. However, hand dusters should not be depended upon for trees that have grown too large because it is difficult to reach properly the top portions of the tree with a hand duster.

Power dusters that are now on the market consist of a motor and a power-driven blower or fan which forces the material through a large discharge pipe onto the trees. The fan should be 12 inches or more in diameter with about six blades making 3500 or more revolutions per minute. Engines of at least 8 horsepower are preferred. The experience of most growers with dusters has been that it is advisable to have a powerful engine to secure satisfactory placement of dust on large trees.

DUST MIXERS

A dust mixer allows formulae to be made up fresh as needed to suit the local conditions at a considerable saving in cost. Some dusters are equipped with mixers so that the dust materials can be put into the hopper, thoroughly mixed together, and then blown out through the discharge pipe. For dusters that do not have this feature, a dust mixer can be purchased. Where small quantities of dust are used, it is often better to buy factory-mixed dusts.

COST OF SPRAY AND DUST APPLICATIONS

Spraying costs average between 25 and 30 per cent of the production costs in most Ohio orchards. The total cost of spraying is divided about equally between cost of materials and labor, including equipment charges. Costs vary, depending upon the formula used and the efficiency of application. Under conditions necessitating the use of nicotine, strong lime-sulfur solutions, or some of the oils, the cost of materials may exceed the cost of application.

The cost of application during the seasons of 1930 and 1931 at Wooster was 62 cents per 100 gallons, where the material was applied with a sprayer having a capacity of 30 gallons per minute and applying 400 gallons of solution per hour. Man labor was charged at 35 cents per hour and team labor at the same rate. The cost of applying 100 gallons of solution was $1.20 during the 5-year period from 1925 to 1929, using a sprayer and water supply that

permitted the application of but 200 gallons per hour with labor at the same rate as in 1930 and 1931. In each of the above calculations liberal allowance was made for depreciation, repairs, and operating cost of sprayer and water supply tanks, but in neither case is the cost of material included.

The cost of applying dust at the rate of 200 pounds of dust per hour, using the same labor rates as for spraying, was 82 cents per 100 pounds. The price of the dust was not included in this cost.

TROUBLES CONTROLLED BY METHODS OTHER THAN SPRAYING

FIRE BLIGHT

Blossom blight, which is one form of fire blight, is most severe throughout southern Ohio. In northern Ohio vigorously growing trees of susceptible varieties are sometimes attacked by blossom blight but are more likely to be infected with twig blight, which is another manifestation of the same disease. Extremely susceptible varieties, like Tompkins County King, develop limb and body cankers if the disease is permitted to spread unchecked.

In southern Ohio, spraying with 1-3-50 bordeaux mixture in full bloom has been practiced by some growers for a number of years. While this application reduces the amount of blossom blight, it is not a satisfactory control during severe outbreaks. In addition to being an inadequate control, severe russetting may be caused by applications of bordeaux at blossom time. Where blossom blight is a perpetual problem, it is suggested that a bordeaux spray be applied when one-third of the blossoms has opened. Arsenate of lead should not be included with this spray. Cutting out of blossom blight is not advised.

Twig blight may be controlled in the northern part of the State by removing all blighted twigs and body cankers during September and October. At this season of the year it is not necessary to use a disinfectant on the pruning tools. If blight is cut out in the spring of the year or during the summer, a disinfectant made by dissolving two tablets of bichloride of mercury and two tablets of cyanide of mercury in 1 quart of water should be used. A rag or sponge tied to the end of a stick makes a convenient swab for the larger pruning shears or saw. This mixture should be carried in a glass or wooden vessel. *It is extremely poisonous and should be kept out of the reach of children and livestock.*

PEACH TREE BORERS

GAS TREATMENT FOR BORERS LOCATED AT OR BENEATH THE GROUND SURFACE

Paradichlorobenzene, sometimes called P. D. B., Paracide, and by other trade names as well, is now widely used to control the peach borer located at or just beneath the ground surface. This material is sold as fine granulated crystals. If used according to the following directions the results are satisfactory.

Directions for using paradichlorobenzene.—One ounce of the chemical is advised for treating a full grown tree and from ½ to ¾ of an ounce on trees from 3 to 5 years old, depending upon the size of the trees. Not more than 1½ ounces should be used in any case. Trees less than 3 years of age should not be treated unless very badly infested. Such young trees are likely to be injured by the chemical.

1. Apply in the latter half of September or early October when the soil is dry. This will kill the borers while young and after all eggs are hatched. The temperature of the soil at time of application should be above 55° F. for best results. If fall treatment has not been made and the life of the tree is threatened, a spring application can be made as soon as the soil temperature becomes high enough. This is usually about May 15.

2. Clear off the trash about the base of the tree for a distance of 6 inches from the trunk. Do not dig into the surface crust more than necessary. If considerable gum is present about the base of the tree, remove this before treating. Have the soil surface level with the point of highest exudation of sawdust or gum and, if necessary, mound the dirt to this point. The greatest number of borers will be killed if this is observed, as the gas given off by the chemical is heavier than air and is most effective below the application.

3. The crystals of paradichlorobenzene are then evenly distributed in a narrow, continuous circular band on the soil about the tree. Place this ring about 2 inches from the trunk. Have the band about 1 inch wide, and none of it closer than 1 inch to the trunk (or large roots); otherwise injury might result.

4. Place several shovels of soil (free from trash) over the ring of chemical. Pour the first shovelfuls of fine soil carefully against the base of the tree. Cover chemical about 3 inches deep with a cone of earth. Compact this with the back of the shovel or with the foot.

5. Airing.—Three to 4 weeks after application, remove the mound of earth from the base of tree younger than 5 years. If the soil has been wet, wait from 5 to 6 weeks before uncovering. This is a precaution against possible injury to the trees and should always be done to young trees. It is not necessary to remove the mounds from older trees. However, these mounds of earth should be leveled off in the spring.

PAINT TREATMENT FOR BORERS LOCATED ON THE TRUNK AND LARGER LIMBS

Fumigating with dry paradichlorobenzene crystals is not possible for controlling the lesser peach borer which works entirely above ground on the trunk and older limbs. Considerable gum exudation is always found at points of larval feeding which appear at abrasions on the trunk and in the crotches of the older limbs. Control consists of painting these wounds with crude cottonseed oil in which paradichlorobenzene has been dissolved.

Directions for preparing and applying paint.—To prepare the mixture, dissolve 1 pound of paradichlorobenzene crystals in 2 quarts of crude cottonseed oil, previously warmed. Apply this mixture with a paint brush so that the bark is covered well beyond the edges of borer indications. Removal of gum, grass, or loose bark from the infested areas is not necessary. There has been no discernible injury to peach trees so treated, but the paint should not be sprayed on or covered over more of the surface than necessary. The application should be made during mild weather, the latter half of April or early in October. At this time of year the work of borers is easily visible.

It is preferable to use freshly prepared material. If the mixture is stored for a few days, place it in an air-tight container. Linseed oil can be used instead of raw cottonseed oil, but it is not as easy to apply, being thicker and more sticky.

RODENTS

It is extremely discouraging to a fruit grower to lose one or more of his best trees because of injury from rabbits or mice. There are several methods the grower may use to prevent such rodent injury.

TREE PROTECTORS

Trunks of young trees may be protected against rabbit, woodchuck, and mouse injury by the proper use of wire guards. Guards made from quarter-inch-mesh galvanized hardware cloth make an excellent protector. A cylinder of sufficient height and diameter can be made from squares cut from 24-inch width of this hardware cloth. This is high enough to prevent rabbit injury and, if pressed in the soil to a slight depth, will usually prevent mice from reaching the trunks. A convenient way to secure the cylinder is to use three or four hog rings at the lap of the wire.

A method of protecting trees that is used frequently against mice is to remove some of the soil from around the base of the trunk in the fall and fill in with several shovels of weathered or leached cinders. This is an effective barrier against mice as long as mulch or trash does not collect on top of the cinders. This does not prevent damage when snow is on the ground or to the older roots that are near the surface.

RABBIT PAINT

The trunk and lower branches of young fruit trees may be protected against gnawing injuries from rabbits by painting with a resin-alcohol repellent in the fall before rabbit injury occurs and by giving later applications as necessary. Usually one thorough application in the fall is sufficient each year, but where rabbits are very numerous an additional application may be needed in midwinter.

Method of preparing rabbit paint.—Use resin and alcohol in the proportion of 1 pound of resin to 1 pint of denatured alcohol. Warm the resin over a slow fire just to the melting point but do not superheat it. Heat the alcohol to about the temperature of the resin. Do not heat the alcohol over a direct flame but warm it in a pan or bottle immersed in hot water. Add the heated alcohol to the melted resin and stir to an even consistency. If the resin is too hot the alcohol will bubble and escape. Immediately place the preparation in a container that can be corked or sealed and keep sealed, except when in use. Keep snow and rain water out of the preparation as moisture changes the texture of the paint.

Apply with a brush when bark is dry. Cover bark of trunk and lower limbs as far as rabbits can reach. Allow for snow which may permit rabbits to work higher on the trees.

Resin-alcohol rabbit paint covers easily, is economical, and has been extensively used under Ohio conditions and found very effective in preventing rabbit damage.

Where neither wire guards nor repellents have been used, some degree of protection against rabbits can be secured in an emergency by scattering freshly cut prunings on the snow. The rabbits will often feed upon these in preference to the tree trunks.

POISONED BAITS FOR MICE

Removing all weeds and grass from the area around the tree trunk in the fall is always advisable to guard against mouse injury. However, when mice are abundant, the use of poisoned baits is the only dependable method to use.

Poison stations.—The bait should be placed in poison stations which are set close to the base of the tree and lightly covered with vegetation or prunings. If mice are abundant, place one station under each tree. The stations should be on high ground to avoid standing water. They are preferably made of wood and may consist of pieces of board and lath nailed together to make a small mouse runway and also to shelter the bait. Drain tiles of 1½-inch diameter, or larger, or hollow building tile serve fairly well. Wide-mouth, glass jars have been used successfully. The stations should be refilled with bait as required. Baiting should be done late in the fall and again during the winter or early spring if necessary.

The following formulae for preparing mouse bait are recommended by the Bureau of Biological Survey, United States Department of Agriculture.

Rolled-oat bait.—Mix together, dry, ⅛ ounce of powdered strychnine and ⅛ ounce of baking soda. Sift the strychnine-soda mixture over 1 quart of rolled oats, stirring constantly to insure an even distribution of the poison through the grain. Thoroughly warm the poisoned rolled oats in an oven and sprinkle over them 6 tablespoonfuls of a mixture of 3 parts of melted beef fat and 1 part of melted paraffin, mixing until the oats are evenly coated. When the grain is cool it is ready for use.

A teaspoonful of the bait should be placed in each poison station. This poison may also be placed inside the entrances of burrows. It should not be scattered in the open where birds will feed upon it.

Starch-coated grain bait.—Mix 1 tablespoonful of gloss starch in ½ teacup of cold water and stir into ¾ pint of boiling water to make a thin clear paste. Mix 1 ounce of powdered strychnine with 1 ounce baking soda and stir into the starch to a smooth, creamy mass free of lumps. Stir in ¼ pint of heavy corn sirup and 1 tablespoonful of glycerine. Apply to 12 quarts of wheat or to 20 quarts of steam-crushed whole oats and mix thoroughly to coat each kernel.

Steam-crushed whole oats are preferable as they may be scattered in the open without endangering bird life. This bait is prepared each summer at the Idaho Field Station of the U. S. Biological Survey and shipped at cost to local farm organizations which send in their orders. For information about this, growers should consult their county agent or state agricultural college.

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